Consequences of massive bird releases for hunting purposes: Mallard *Anas platyrhynchos* in the Camargue, southern France

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Abstract

The release of captive-reared fish and game animals into the wild is a common management practice in Europe and North America. In Europe, millions of reared birds are released each year yet the consequences of these release programmes have received little attention. This paper describes the massive introduction of Mallard *Anas platyrhynchos,* a native migrant species released into the wild to increase the size of hunted populations. It provides the rationale for current and forthcoming experiments aimed at determining the effects of the augmentation of Mallard stocks on wild population genotype and survival rates.

Key words: *Anas platyrhynchos*, demographic structure, genetic structure, Mallard introduction, stocking, survival.

The accidental or deliberate release of alien species is one of the main causes of animal extinction (Chapin *et al.* 2000; Clavero & García-Berthou 2005; Lockwood *et al.* 2007). Besides the introduction of exotic animals or plants, individuals of native species are also often released into the wild (Laikre *et al.* 2006). Two common reasons for such releases are to rescue populations that have declined to critical levels, and to supplement natural stocks for exploitation purposes. The latter is often associated with leisure angling and shooting (Griffith *et al.* 1989; Fischer & Lindenmayer 2000; Meek *et al.* 2003). Potential effects of releases include demographic impacts on wild populations and genetic pollution (Arroyo & Beja 2002). Both demographic and

genetic effects are expected in restocking, which can be defined as the release of animals for reinforcing or re-establishing a local breeding population (Hodder & Bullock 1997). Nevertheless, the effects of large-scale supplementation of native species on wild populations remain poorly understood.

Although massive releases usually result in short-term increases in population size, studies to date indicate that few of these individuals join the breeding population. For instance, galliform mortality is high in the weeks following their release and the individuals that survive to the next breeding season have low rearing success (Dowell 1992; Sokos *et al.* 2008). In Mallard, there is some evidence that mortality rates are higher for captive-reared birds than for wild ones, mainly due to a higher vulnerability to hunting (Fog 1964; Dunn *et al.* 1995). However, the proportion of released Mallard that survive the hunting period, and then mix and interbreed with wild conspecifics, is still not known (Brakhage 1953; Yerkes & Bluhm 1998).

This paper presents the rationale for a research project that has been initiated to assess the demographic and genetic effects of restocking. Mallard *Anas platyrhynchos* was selected as a model species for investigating the potential effects of large-scale releases on wild populations because very large numbers are introduced into the wild in Europe each year for hunting purposes (probably > 1,000,000 birds; Laikre *et al.* 2006; Mondain-Monval & Girard 2000). The study aims to determine the survival rates of released Mallard and the proportion that survives the hunting period. Whether the birds are able to find food in the wild, whether they reproduce and the extent to which they contribute to the genetic stock of the species is also being assessed. This paper outlines the experiments planned for investigating the medium- and long-term viability of Mallard released into the wild.

Study area

The study will be carried out in the Camargue (43°30'N, 04°40'E), an alluvial wetland covering some 140,000 ha in the Rhône delta, southern France. Situated at the crossroads of numerous migratory routes of Palaearctic birds, the Camargue is a site of international importance to waterbirds (Berthold 2001; Kayser *et al.* 2003). The area is considered to be a particularly important wintering site for Anatidae (Tamisier & Dehorter 1999). More than 85,000 ha of the delta are wetlands, of which 71% are divided into more than 200 private, commercial and communal estates where hunting occurs (Dehorter & Tamisier 1996; Mondain-Monval *et al.* 2009).

Survival rate assessment

Three approaches will be used to investigate Mallard survival: 1) a descriptive demographic analysis using ring recovery data to compare survival rates before the massive releases commenced (*i.e.* pre-1970s) with the current situation, after 30 years of massive releases in the area, 2) an experimental release and ring-recovery analysis for hand-reared and wild birds under controlled hunting pressure conditions, and 3) an assessment of how well hand-reared Mallard are able to feed in

the wild after being raised in an area where food is provided, which may affect food capture efficiency as well as digestive ability (Liukkonen-Anttila *et al.* 2001). These three approaches are described in further detail below.

Demographic study of historical versus modern data

Massive releases of Mallard started to become common practice in the Camargue in the 1970s (Mathevet unpubl. data) and have occurred at an increasing rate over the last 30 years (Tamisier & Dehorter 1999). At least 30,000 Mallard are currently released annually (Isenmann 2004; Champagnon *et al.* unpubl. data). The release of captive-reared animals over such a long period may result in lower average fitness for individuals in the wild population (Gross 1991; Guyomarc'h 2003; McGinnity *et al.* 2003). For instance, measurements of wild Mallard caught in France over a 30-year period (*i.e.* over several generations) found a 10% decrease in lamellar density in the proximal part of the bill, a crucial morphological area for food filtration in dabbling ducks (Champagnon *et al.* unpubl. data). The underlying hypothesis being tested here is that massive stocking of hand-reared Mallard has reduced the fitness of the Mallard population as a whole.

Ducks were ringed in very large numbers in the Camargue before the stocking programme started (*e.g.* Guillemain *et al.* 2005 for Teal *Anas crecca*). Ducks were caught in baited dabbling duck funnel traps at Tour du Valat (43°30'N, 04°40'E) from 14 March 1952–30 December 1969. This constitutes the "historical" part of the dataset being used in the analysis (n = 6,156 birds). The "modern" sample consists of 1,607 Mallard caught using the same method, which were ringed and measured between 23 October 2002–3 March 2009 at the Marais du Vigueirat (43°31'N, 04°47'E), a few kilometres from Tour du Valat (Guillemain *et al.* 2009). Multi-state capture-recapture models will be used to estimate annual survival rates for Mallard over the two periods, while controlling for sex and for age classes. Clearly this BACI (Before-After-Control-Impact) experiment is insufficient for providing unequivocal conclusions, because the increase in release was progressive and because several confounding variables such as changes in climate and overall hunting intensity may influence annual survival rates. A controlled experiment will therefore be used to compare survival rates for wild and released individuals over the next few years.

Experimental release of Mallard

In France, stocked Mallard are generally released at the age of 6–9 weeks, about two months before the start of the hunting season. In order to keep hand-reared Mallard on the hunting estate, provision of corn, wheat or rice on the fields is common practice. Hand-reared Mallard therefore are likely to be highly faithful to the place where they were released until the hunting season commences. During this period, hunting estates may be considered as a type of nature reserve (Legagneux *et al.* 2009). Nevertheless, as the hunting season begins such birds become highly vulnerable to local hunting mortality. Because stocked Mallard are thought to remain close to the baited

release site, and because hunters may be able to approach these birds more easily as they are more used to humans, hunting pressure is expected to be higher on released Mallard than on wild birds, at least early in the hunting season.

Differences in survival rates recorded for introduced and wild Mallard have, to the best of our knowledge, never been investigated. This part of the study therefore aims to test the hypothesis that differential hunting mortality exists between released and wild individuals. To achieve this, juvenile captive Mallard will be released at hunting estates where stocking and release has not been practised (n = 450 birds in three estates, replicated over two successive years in 2009–2010). Similar releases will be made at a nature reserve where no hunting is practised (n = 300 birds released per year in 2009–2010). Wild juvenile Mallard hatched in the Camargue will be captured and ringed during the same period for a comparison of survival rates recorded for birds raised under these two conditions (natural wetlands versus aviary). To control for any potential age effect on survival (Gunnarsson *et al.* 2008), all wild birds will be caught at the age of 6–9 weeks, which is also the release age for stocked Mallard. In addition to a metal ring, all birds will be fitted with a nasal saddle of the type described by Rodrigues *et al.* (2001), already used in the Camargue for Teal *Anas crecca* (Guillemain *et al.* 2007a), to determine weekly local survival rates derived from successive re-sightings of the saddles. If hunting is indeed the main source of mortality and hunting pressure is indeed higher on stocked birds than on wild Mallard, it is expected that hand-reared birds would have higher mortality rates than wild Mallard within the hunting estates. There should, however, be no difference in survival between hand-reared and wild birds in areas where hunting does not occur, such as on nature reserves.

In the longer term, the study will also assess survival patterns for released birds in years after the first hunting season. Because such birds are expected to learn to avoid areas with high levels of hunting activity (Guillemain *et al.* 2007b), we hypothesise that there would be little or no difference between hand-reared and wild birds in their annual mortality rates in the second and subsequent years following release.

Adaptation of stocked Mallard to foraging in the wild

Previous studies have shown that released individuals of native species may be less able than their conspecifics to adapt to changes in the natural environment (Robertson *et al.* 1991; Brittas *et al.* 1992). Because the birds' diet may change markedly over the annual cycle (for instance, some species shift from feeding on seeds in winter to invertebrates in summer; Arzel *et al.* 2009), wildfowl have highly adaptable digestive tracts, especially in terms of gut length and stomach volume (Charalambidou *et al.* 2005). The study therefore will also compare the size and mass of digestive organs (proventriculus, gizzard, small intestine, caeca, rectum and liver) of wild and captive-reared Mallard. Moore & Battley (2006) showed that released Brown Teal *Anas chlorotis* have shorter and lighter organs than wild ones and suggest that captive-bred Teal could

have a reduced ability to digest a wild diet efficiently in the weeks following release. However, studies of captive birds indicate that switching from a commercial diet to a natural diet may trigger phenotypic response in gut morphology. For instance, it has been shown that captive Mallard put on a high-fibre diet are able to increase their digestive organs in weight and length (Miller 1975; Kehoe *et al.* 1988). Hand-reared Mallard therefore may be inefficient in feeding on wild food items upon release, but their digestive tract may then adapt to the new food supply relatively quickly.

This part of this study aims to assess the rate at which such adaptation of the digestive tract occurs, and to investigate whether initial maladaptation of the gut may lead to higher mortality rates during the first weeks of life in the wild. This will be achieved by regularly collecting and dissecting ringed and non-ringed (presumed wild) individuals from the hunting bag of estates participating in the experimental release programme. In addition to gut anatomy, the diet of the birds will be determined through examination of the contents of the gut. In particular, the relative dependence of hand-reared and wild birds on bait spread by hunters, which resembles the food provided to Mallard in aviaries, will be determined.

Genetics studies

Released individuals originating from captive stock may differ genetically from the wild birds with which they subsequently interbreed (Duarte & Vargas 2004; Blanco-Aguiar *et al.* 2008). Waterfowl breeders eliminate individuals with obvious phenotypic aberrations. Nevertheless domestic birds are likely to have been selected and bred for traits such as egg production, survival or aggressiveness (Robertson & Dowel 1990). Domestication may also affect traits through a relaxation in natural selection (Araki *et al.* 2007). The objective of the genetics analysis within the Mallard study is to assess the potential breeding success of hand-reared birds that have been released to the wild by measuring genetic introgression of stocked Mallard within natural populations using different genetic markers.

Samples of wild Mallard tissue will be obtained from museum specimens collected from different parts of France before the 1970s (before substantial supplemental stocking of Mallard occurred at least in the Camargue). Samples of hand-reared Mallard feathers will be obtained from a selection of 20 breeding birds selected randomly from breeding birds in each of two game farms over France. Using microsatellite markers (Maak *et al.* 2003; Denk *et al.* 2004; Huang *et al.* 2005) and mtDNA sequences (He *et al.* 2008), we will assess genetic differences between hand-reared populations and wild birds. As a consequence of breeding aviaries selection, significant structure of population is expected.

The present "wild" Mallard population is potentially a mixture of truly wild birds, farmed birds recently released in surrounding estates, and individuals descending from birds from both sources. Comparing the genetics of the current "wild" Mallard population with the hand-reared Mallard populations and the

historical wild Mallard population, we could estimate genetic introgression of hand-reared birds. In addition, the tools developed here will help in discriminating wild from stocked Mallard when caught or killed. There is currently no accurate method for determining the origin of a bird caught or retrieved in the wild. This will greatly help in understanding the dispersion, vulnerability and ecology of hand-reared Mallard populations.

Overview

There is currently a major gap in knowledge regarding the consequences of massive Mallard release programmes in France and elsewhere. The research described here will use a novel multi-disciplinary approach to assess these effects. The studies presented here may also provide a suitable framework for similar research on other re-stocked birds, mammals or fish. Such actions seem increasingly called for, as stocking for leisure activities (in particular for hunting and fishing) is a widespread practice in many countries, and with effects that may potentially reach far beyond the local release sites.

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